Amendments to the Specification

Page 23, after line 2, insert the following paragraphs

-- As illustrated in FIGURES 1, 2 and 4, spray apparatus can operate within a rotating drum disposed in a generally horizontal orientation. The drum may incorporate internal lifting flights which lift free-flowing (e.g. seed and growing seed capsule) particles in the drum and then let the particles fall to the bottom of the drum as a continuously falling curtain or cascade. In some embodiments, the interior of the drum is either clean and free from any fighting, or has only mixing fingers or flights that expand the area by the bed, that keep the bed rolling as the drum rotates, and that generally improve mixing, rather than lifting particles to the top of the drum and then releasing them in a falling cascade. However, such lifting of particles to the top of the drum, and corresponding falling cascade or falling curtain, are not excluded from processes of the invention. Rather, both such finger mixing, and such lifting coupled with falling cascade or curtain, are included within the scope of the invention.

Stationary spray nozzles are positioned within the drum to project the sprayed material onto the rolling bed, and optionally onto any curtain or cascade of falling particles. For a continuous process, the drum is preferably inclined at a small angle from horizontal, such as, without limitation, about 0.25 inch to about 0.38 inch from the horizontal for each foot of length of the drum, so that rotation of the drum causes the particles to move from the inlet end of drum to the discharge end, while maintaining a relatively uniform bed thickness. The optimum degree of incline varies with each set-up and may thus be outside the above range. The important parameter is to contribute to

maintaining a bed of seed and seed capsule particles having sufficient uniformity that the spray material can be effectively applied to the particles passing through the drum. The particles are then discharged at the discharge end of the drum.

Figures 1 and 2 show schematically a first embodiment of the processing equipment which may be used to produce seed capsules of the invention. Such processing equipment includes a drum and sprayer combination suitable for continuously producing coating seed capsules in accord with the invention. Use of the illustrated drum and sprayer combination is not critical, however, as other drum and sprayer combinations, or other coating methods such as pan coating methods, are also suitable. In FIGURES 1 and 2, drum 10 has an inlet end 12 for receiving the substrate seed material or materials, or partially formed or pre-coated seed capsule precursors. Drum 10 has a discharge end 14 through which agglomerated or otherwise coated seed capsule product particles are discharged over discharge retaining ring 16. A variable speed rotary drive (not shown) is provided for supporting and rotating the drum 10 in a counterclockwise direction as viewed in FIGURE 1 at controlled, and changeable drive speeds. Conventional slope adjustment apparatus (not shown) is provided for routine and ongoing adjustment the slope of the drum from horizontal.

Air is preferably supplied from discharge end 14 as shown in FIGURE 2, and flows countercurrent to the direction of travel of the seed substrate material. Since the contemplated coating materials are generally applied to the seed in liquid, or semi-liquid, or other moist form, and since some coating materials may thus tend to form clumps or other wise self-agglomerate when exposed to ambient moisture conditions,

air supplied at discharge end 14, and elsewhere in the process for contact with the coated seed and seed capsules, is preferably dried in order to cost-effectively remove an optimum amount of the moisture from the coating material and to assist in maintaining suitably low moisture content in the thus coated and dried seed capsules.

A first stationary spray assembly 28 extends longitudinally within drum 10 above and adjacent the bed 20 of seed and/or seed capsules. First spray assembly 28 includes pipe 29 and nozzles 30. A second spray assembly 32 extends longitudinally within drum 10 generally adjacent first spray assembly 28. Second stationary spray assembly 32 includes pipe 33 and nozzles 34, which transport the material to be sprayed. Nozzles 30 and 34 are connected to pipes 29 and 33 respectively, and project sprays of liquid or otherwise particulate coating material toward the bed of seeds and/or seed capsule precursors. The description of spray assemblies 28, 32 as stationary means that the spray assemblies to not rotate with drum 10. However, the positions of either nozzles 30, 34 or pipes 29, 33, or both, can be adjusted within the drum for proper direction of the respective spray or sprays onto the bed of seeds and/or seed capsules or seed capsule precursors.

A stationary protective cover 24 is mounted over the spray assemblies. Seeds and/or seed capsules falling from the inner surface of the drum and the flights, above the spray assemblies, fall onto the cover, and are deflected away from the spray assemblies, as shown in FIGURE 1. Thus, cover 24 protects the pipes and nozzles from the falling seeds and seed capsules falling onto and fouling the pipes and spray nozzles.

As drum 10 rotates, flights 22 lift and mix the seeds, seed capsule precursors, and seed capsules, but do not generally carry the bulk of the seeds and seed capsules up to the top of the drum. Some small amount of seeds, seed capsule precursors, and seed capsules will be carried upwardly to the top of the drum by even a drum devoid of any flights. Thus, all drums experience some amount of seeds and seed capsules falling from the upper part of the rotating drum whereby cover 24 is beneficial for protecting spray assemblies 28 and 32.

Preferred flights 22 are primarily directed toward enhancing mixing of the bed 20 of seeds and seed capsules, continually refreshing the surface of the bed with a newly-emergent supply of seeds and seed capsules, rather than lifting and subsequently dropping the seeds and seed capsules which may be fragile when initially coated. To that end, each flight 22 preferably, but without limitation, has a leading surface 23A extending at an obtuse angle "A1" of at least 90 degrees with respect to the inner surface of the drum. A more preferred angle "A1" is about 100 degrees to about 150 degrees. Trailing surface 23B of flight 22 can be virtually any angle, with the inner surface of the drum, which angle does not interfere with the operation of adjacent leading surfaces 23A.

Additional retaining rings can be added to the assemblage shown in the drawings, in order to provide that height "H" to the retaining ring which will provide and maintain the optimum configuration of bed 20 inside drum 10.

As noted above, inlet end 12 of the drum may be raised above discharge end 14. When in use, the drum rotates continuously. Seeds or previously thinly-coated or

partially-coated seed capsules are continuously fed into inlet end 12 and thus added to rolling bed 20. Flights 22 continuously mix the bed as the drum rotates, refreshing the bed surface with newly fed seeds, or seeds and seed capsules newly brought to the surface by the continuous rotation of the drum in combination with the mixing action of the flights. Spray assembly 28 sprays the desired coating material (e.g. sewage sludge, paper mill sludge, or other coating composition, onto the continuously moving and mixing surface of the bed 20 from a plurality of nozzles 30 distributed along the length of pipe 29, and similarly along the length of drum 10, adding the sprayed material to the seeds and seed capsules in bed 20. After receiving the spray coating from spray assembly 28, the seed capsules are discharged through discharge end 14. In some embodiments, the seed capsules pass through a cooling chamber, not shown integral in drum 10, before being displaced through discharge end 14.

In general, as the seeds traverse the drum, from inlet to discharge, nozzles 30 atomize the liquid or other coating material and spray such atomized coating material as e.g. droplets of the coating material onto the seeds in the bed. The result is that the seeds become generally uniformly coated with one or more layers of the coating material such that the coating material becomes an integral part of the respective seed capsules fabricated in the drum. As the coating material solidifies on the seeds, the coating material tightly bonds to the respective portions of the seeds.

As the seeds and seed capsules roll and mix with rotation of the drum, the incline of the drum causes the seeds and seed capsules to travel from inlet end 12 toward discharge end 14.

In the alternative, or where a coating material is not readily self-bonding to the seed material, a binder material can be provided toward the inlet end of the drum at spray assembly 32, through pipe 33 and nozzles 34. In such embodiment, the binder is preferably sprayed onto the seeds closer to inlet end 12 rather than along the entire length "L" of the drum. The coating material is then preferably sprayed onto the seeds downstream from the inlet end, and preferably relatively downstream of nozzles 34. Thus, the seeds receive a first coating of the binder, and a subsequent second coating of e.g. liquid soil conditioning coating material overlying the binder.

Binder material applied as e.g. through spray assembly 32 may contain additional coating components such as e.g. flyash, lime, gypsum, or the like, as one or more components for assisting in adding bulk and thickness to an inner binder layer prior to any, or the majority of, the application of the organic coating material (e.g. sewage sludge or paper mill sludge).

Regarding the coating process, FIGURE 4 illustrates in flow sheet form manufacturing process for producing seed capsules of the invention, using the coating drum 10 as described above. It should be understood, however, that other equipment such as a pan pelletizer, a paddle mixer, or the like can be used in place of the rotary drum to obtain combination seed capsules of the invention.

Referring to the drum of FIGURES 1 and 2, and to the pan pelletizer block in F IGURE 3, the seeds are fed continuously to an inlet as at inlet end 12 of drum 10. Combination seed capsules, produced as described above, are released from a discharge end 14 of the drum to a sizing apparatus 36 in which the seed capsules are

sized through conventional sizing elements. Suitably-sized seed capsules are discharged from the sizing apparatus as product for distribution. Undersize seed capsules are fed back into mixer as shown in FIGURE 3. Oversized seed capsules are fractured and screen for reprocessing.

EXAMPLE 1

A coating drum as illustrated in FIGURES 1, 2 and 4 is used to place a coating of paper mill sludge on grass seed. Raw material grass seed about 4-6 millimeters long and about 0.5-1.0 millimeter thick, is continuously fed to pre-treater 11, where the seed is blended with powdered lime, powdered flyash, and a lignosulfonate binder, to form partially-developed seed capsules comprising seeds coated with relatively thinner coatings of the recited mixture of coating materials. The partially-developed seed capsules are continuously fed to inlet end 12 of drum 10, to form a bed 20 of the partially-developed seed capsules. The drum rotates continuously. The rolling of the drum, and the associated mixing affect of the flights, provide a constantly changing top surface of the bed. A paper mill sludge slurry is supplied in pipe 28 at pressure sufficient to atomize the liquid sludge slurry. A liquid sludge slurry is thus sprayed from nozzles 30 onto the top surface of the bed of partially-developed seed capsules, applying a sludge coating on those partially-developed seed capsules which are at the upper surface of the bed at any given point in time.

The resulting seed capsules, of paper mill sludge coated seeds, have a coating of solid conditioning sludge thick enough to make the material a product marketable for its soil conditioning content as well as for the seeds contained therein. Increased levels of

nitrogen and/or other plant nutrients can be added by, without limitation, providing sprays of the other desired materials, preferably subsequent to at least the initial sludge slurry spray. Other materials can be included in one or more of the sprays e.g., to retard or enhance moisture permeation into or out of the combination product in accord with the anticipated storage and/or use environment of the product.

EXAMPLE 2

FIGURE 5 illustrates the equipment used in this EXAMPLE 2. As seen therein, grass seed, lime, flyash, and calcium lignosulfonate binder are fed to ribbon blender 111 by respective screw feeders 112A, 112B, 112C, 112D respectively. Ribbon blender 111 encapsulates the seed with a thin layer of the mixture of lime, flyash and lignosulfonate to thereby make partially-formed seed capsules. The partially-formed seed capsules are discharged from the ribbon blender and conveyed by conveyor 114 and belt feeder 116 to a tilted-pan pelletizer 118, which rotates about a fixed axis.

Paper mill sludge is received into a weigh hopper 120 at about 60% by weight water, and is fed by screw feeder 122 and belt 124 to pin mixer 126. The pin mixer breaks down the fiber and fiber clusters of the sludge into loose separate fibers, and discharges the resultant material onto conveyor 128 which transports the material to screw feeder 130, and thence into the tilted pan pelletizer.

In the titled pan pelletizer, the partially-formed seed capsules, (seeds being coated with lime, flyash, and lignosulfonate) are mixed with the comminuted paper mill sludge and thereby coated with the sludge. By operation of the tilted rotating pan pelletizer, the larger seed capsules generally rise to the top of the bed of seed capsules

in the pan, and as additional material (sludge and partially-formed seed capsules) are added to the pan, the larger seed capsules overflow the lower edge of the rotating pan, onto vibrating feeder conveyor 132.

The vibrating feeder conveyor feeds the seed capsules into granulator 134 (e.g. rotating drum) where the seed capsules may be (e.g. spray) coated with inorganic fertilizer or other desired material.

From the granulator, the seed capsules flow into dryer 136 and are dried to a final product moisture of about 2-3% by weight water. The resultant product is then screened by screen 36 and sized as before by sizing mill 37, with undersized and oversized product seed capsules being recycled for further processing.

Referring now to FIGURES 6A-6D, in the embodiment of FIGURE 6A, seed capsule 38A comprises a seed 40A coated with a single generally homogenous coating 42A. Coating 42A, as illustrated in FIGURE 6A, may comprise only the soil conditioning material (e.g. paper mill sludge or sewage sludge), or may comprise both the soil conditioning material and an inorganic fertilizer or other inorganic material generally dispersed in coating 42A.

In FIGURE 6B, seed capsule 38B comprises a seed 40B coated with a first layer 42B of solid conditioning material. A second coating material is shown penetrated partway through the first layer 42B, thus to make a combination outer layer 44B comprising the combination of the material of layer 42A and the material of the second material, such as inorganic fertilizer.

In FIGURE 6C, seed capsule 38C comprises a seed 40C coated with a first layer 42C of soil conditioning material. A second generally separate and distinct layer 46C of a second coating material (e.g. inorganic fertilizer) is disposed outwardly on the underlying first layer 42C. Layer 46C generally does not penetrate layer 42C, whereby higher levels of inorganic fertilizer may be used because of the effective displacement distance between the seed and the second layer 46C. The second layer may be prevented from penetrating the first layer by applying e.g. an intervening layer which repels the second layer, for example was, lignin, or the like.

In FIGURE 6D, seed capsule 38D comprises a seed 40D coated with a pre-coating layer 48D of dicalcium phosphate to densify and configure the seed capsule precursor for the primary coating steps in drum 10 or pan pelletizer 118. Layer 42D of soil conditioning material is disposed outwardly of pre-coating layer 48D. Other materials such as at layers 44B or 46C can be added to any of the embodiments including that of FIGURE 6D to provide the properties associated therewith.

Referring to FIGURE 7, a population of seed capsules 38 are disposed at the top surface of a cross section of soil. Root zone 150 of the soil is generally defined to that depth of the soil which typically receives roots of growing plants, and is generally defined within 20-30 inches of the top surface of the soil. Generally, and preferably, the root zone should have a soft texture, rich in organic and/or other soil conditioning material in order to provide good tilth, and desirable moisture and nutrient holding properties. Underlying root zone 150 is subsoil 152 which typically contains little organic matter.

It is a well known agricultural phenomenon that, in soil used for intensive crop production, the root zone tends, over time, to become relatively depleted of organic solid conditioning material, illustrated at 154 in FIGURE 7, negatively affective soil tilth and texture. While wholesale addition of organic soil conditioning material can improve the overall tilth of the soil, FIGURE 7 illustrates application of the invention wherein the texture of the material immediately adjacent the seed, namely coating 42, provides beneficial properties attributes to soil having desirable texture.

FIGURE 8 illustrates that coating 42 draws moisture 154 from the soil, into the capsule, where the moisture through second coating 46C releases plant nutrient material into the moisture, as well as downwardly into the soil adjacent the seed capsule, as illustrated at 156. Thus, the root 158 emerging from the seed emerges into an initial growth medium, coating 42, having texture, moisture, and plant nutrient highly advantageous to early plant growth. As root 158 advances further downward, the upper portion of the underlying solid under the capsule where the seed first enters the soil, has also been beneficially affected to the good of the plant by plant nutrients 156, and by moisture attracted or held in the vicinity of the capsule as a result of the presence of the soil conditioning material in the capsule.--